Investigation of U-shaped Plastic Optical Fiber as Refractive Index Sensor for Liquids Assessment

L.S.Supian[a], Noor Hamisah Mohd Sahroni[b], Chew Sue Ping[a], Nani Fadzlina Naim[c], Harry Ramza[d]

[a]Department of Electrical & Electronics Engineering, Faculty of Engineering, National Defence University of Malaysia, [b]JKR Headquarters, Kuala Lumpur, [c]School of Engineering, UiTM, Shah Alam, Malaysia, [d]Department of Electrical Engineering, Universitas Muhammadiyah Prof. Dr. HAMKA, Jakarta, Indonesia.

INTRODUCTION

U-shaped fiber optic sensors are fabricated and analyzed to measure the sensitivity of the developed sensor and optimized the detection of the refractive index (RI) of a given liquid. In this research, three types of sensors with different curvature radii (3 mm, 4 mm, and 5 mm) and different angles (30°C and 60°C) with 60 cm length of polymer fibers have been developed to characterize and analyze which type of sensor that will give optimal reading. The research analyzed the RI sensitivity using impurity-free liquid (mineral water) and non-impurity liquid (saline water and used cooking oil). The result is measured and collected using Optical Power Meter and a 6500-input light source. The selection of this U-shaped sensor is due to the robustness of this sensor in various environments, high sensitivity, and its simple construction. This work aims to produce a low-cost and highly optimal U-shaped sensor for detecting and measuring the RI of a liquid impurity and security in any environment. This sensor is expected to be used for future studies such as in bioengineering, food and liquid security and chemical detection.

OBJECTIVES

The objectives of this work are as follow:

1. To develop a refractive index sensor using double side – polished U - shaped Plastic Optical Fiber (POF) which is varied on angle and radii.
2. To demonstrate and investigate the developed sensor using a different RI solution.
3. To obtain optimum performance of the developed sensor based on its sensitivity, absorption, transmission spectrum, and flexibility.

METHODS

The curvature radii, angle, and depth polishing all have an impact on the RI sensing performance. Different RI liquids were used in this experiment to analyze the optimum design of the RI sensor. A U–shaped double sided polished is be fabricated and tested in this experiment as designed shown in Fig. 1.

The basic numerical characteristics of were investigated and characterized such as its length (ι), curve radius (*r*), and thickness (*t*) of the sensor. This sensor then was tested on any liquid solution to sense its performance and to study which sensor will give an optimum result. The bending radius (*r*), deviation angle (θ), and polished depth (*d*) were enhanced to provide better sensitivity.

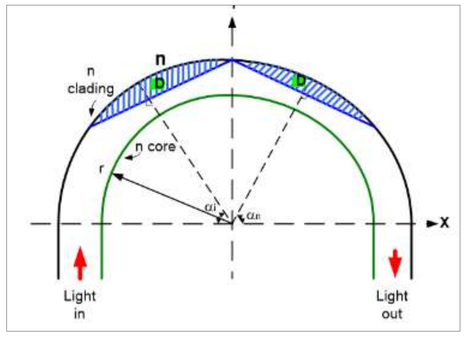

Fig. 1. The structure of the double – sided U – shaped POF.

Three types of liquids which are of pure water, saline and used oil with different RI is used to identify which types of the sensor is suitable for each type of liquid. An amount of 30 ml of liquid was used for this experiment as shown in Fig. 2.

Fig. 2. Experimental setup.

RESULTS

RI sensor with the parameter of 5 mm radii and 30° polishing angle is suitable for saline water RI detection since it has sensitivity near to 1 as shown in Fig. 3 and Fig. 4 depicts sensitivity test for saline water where the value of R squared is 0.7062. Used cooking oil (palm oil) was applied to analyze the stability and the sensitivity of the sensor produce. The refractive index of palm oil increased from 1.457 to 1.4653 after the oil was used in frying. Average R-squared value is 0.766, indicating that the sensitivity is very high as shown in Fig. 5. It is shown that a sample probe for 5 mm radii with a polishing angle of 60° is suitable for this liquid assessment.

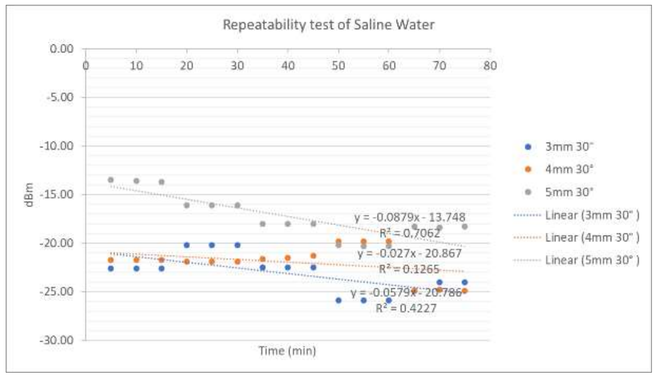

Fig. 3. Repeatability test of saline water

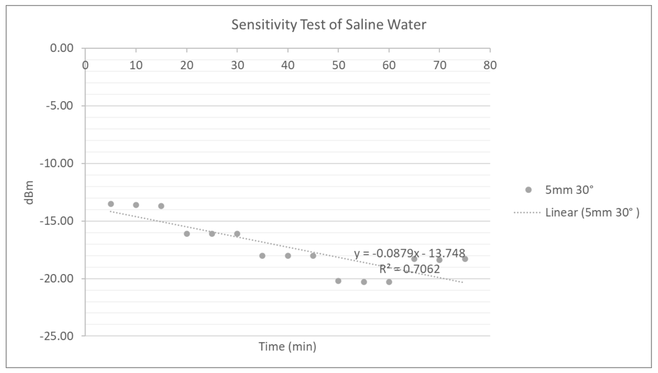

Fig. 4. Sensitiviy test of saline water

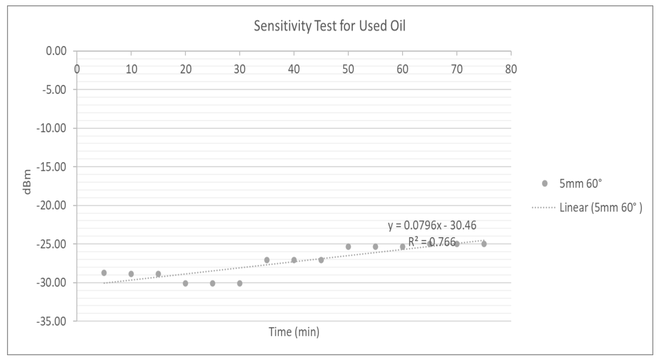

Fig. 5. Sensitiviy test of used palm oil.

CONCLUSIONS

The result shown in previous indicated that the bending radii of 5 mm with a polishing angle of 30° is suitable for saline water detection whilst sensor having bending radii of 5 mm with a polishing angle of 60° is suitable for used oil detection. Respectively it is suitable for RI range from 1.33 – to 1.55 within the temperature of 20°C to 40°C.

REFERENCES

1. H. Y. Wen, H. C. Hsu, Y. T. Tsai, W. K. Feng, C. L. Lin, and C. C. Chiang, “U-shaped optical fiber probes coated with electrically doped gqds for humidity measurements,” Polymers (Basel), vol. 13, no. 16, doi: 10.3390/polym13162696 (2021).
2. Albakri, N., Abdullah, S., Supian, L.S., Zan, S.D., Bakar, A.A.A., “Assessment of Palm Oil Fruit Bunch Maturity based on Diffuse Reflectance Spectroscopy Technique,” 2018 IEEE 7th International Conference on Photonics, 8533172 (2018).